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A durable high performance fibre cement product

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ABSTRACT

The invention provides an engineered fibre reinforced cement product including a surface to which a carbonation reducing sealer is applied so as to reduce differential carbonation in the product. The sealer is preferably a UV curable co-polymer acrylic sealer and desirably is applied to at least a mounting surface of the product. However, in a more preferred form, the sealer is applied to all faces of the product to form a coating of thickness between around 15μm and around 50μm.

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COMPLETE SPECIFICATION

FOR AN INNOVATION PATENT

ORIGINAL

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Invention Title:	A DURABLE HIGH PERFORMANCE FIBRE CEMENT PRODUCT

Details of Associated Provisional Application No. 2003901529 dated 31 Mar 2003

The following statement is a full description of this invention, including the best method of performing it known to us:

File: 38467AUP00

FIELD OF THE INVENTION

The present invention relates to improved high performance fibre cement products having a reduced propensity to carbonation or differential carbonation, and hence increased durability, and to methods of making those products.

The invention has been developed primarily for use in relation to external building cladding panels and will be described hereinafter with particular reference to this preferred field. However, it will be appreciated that the invention is equally applicable to other fibre reinforced cementitious products where improved weathering resistance and durability are important.

BACKGROUND OF THE INVENTION

The following discussion of the prior art is intended to place the invention in an appropriate technical context and facilitate a proper understanding of its advantages. However, any discussion of the prior art throughout the specification should in no way be considered an admission that such prior art is widely known or forms part of common general knowledge in the field.

Fibre reinforced cement (FRC) products are increasingly being used in a variety of building applications and in an increasing range of climatically different situations and geographical regions. Such products have gained favour for their inherent fire, water, pest and mould resistance, as well as their general affordability, which makes them particularly suitable for use in meeting commercial as well as residential building codes.

However, as with timber and other conventional building materials, exposure to the elements inevitably causes chemical changes in FRC products over time. This is due in significant part to the effect of atmospheric carbon dioxide on the cementitious product resulting from a process generally referred to as carbonation.

A growing use of FRC is in external and internal cladding panels which are manufactured by applying a customised finish to the front surface of an untreated FRC board. Such finishes may include various coatings, vinyl films, laminates or the like depending on the final appearance that is required.

While manufacturers of FRC products typically recommend that the rear mounting surfaces of such panels be sealed appropriately, this is not always done, and

even when it is, the FRC manufacturer has no control over the quality of any hidden face sealing that may be applied.

As a result of the above installation practices, some portions of an FRC product may carbonate at different rates depending on the degree of exposure and the integrity of sealers or other surface treatments. When different portions of the same FRC product carbonate at different rates, internal stresses develop. If these stresses are significant they can manifest themselves visually in the form of surface cracking of the panels and/or warping and the like.

While the carbonation process can be controlled to some degree by careful and usually expensive treatment of the FRC products during conversion of the bare board base panel product into a customised cladding sheet, or even more commonly as an additional coating or sealing process on site, it is hard to ensure consistent quality and performance of these subsequent treatments. In addition, the processes involved are time and labour intensive. Similarly, other prior art procedures involving the lamination of a resin sheet to a rear surface of the base board prior to customisation or installation, are unlikely to be commercially viable as the process would be costly, time consuming and limit the subsequent uses to which the resulting FRC board could usefully be employed.

It is an object of the present invention to provide a high performance compressed fibre cement product and methods of making that product which overcome or ameliorate one or more of the disadvantages of the prior art.

DISCLOSURE OF THE INVENTION

According to a first aspect of the invention, there is provided an engineered high performance fibre cement product having a reduced propensity to carbonation or differential carbonation when compared to existing fibre cement products.

In a first preferred form, the product is engineered to have a predetermined permeability to thereby control the rate of carbonation and/or the carbonation gradient through the product.

In a first variation of this first preferred form, the product is configured to define at least one exposed surface to which a customised external finish is to be separately

applied and a mounting surface, wherein a carbonation reducing sealer is applied to said mounting surface.

In a second variation of this first preferred form, the product is configured to have a structure that results in a permeability profile that produces a relatively even carbonation gradient through the product. This may be achieved by varying product density. Preferably, the desired product density is achieved by compressing the product to a predetermined pressure while in the uncured, or "green", state.

In a third variation of this first preferred form, the product permeability may be varied by varying the permeability profile of the product as a whole, and by applying a carbonation reducing sealer to at least one mounting surface.

In a second preferred form, the product is engineered to have a different chemical composition that is selected to reduce its propensity to carbonation.

In a first variation of this second preferred form, the FRC formulation has a cement to silica ratio of between 0.29 to around 0.51 on a dry weight basis.

More preferably, the dry weight basis cement to silica ratio is between 0.36 and around 0.43, and in the most preferred form as used for cladding panels, is approximately 0.39.

According to a second aspect of the invention there is provided a method of making a manufacturer pre-treated durable high performance compressed fibre cement product, the method comprising steps of:

(a) forming by conventional processes a green fibre cement product configured to define at least one exposed surface and a mounting surface;

(b) compressing said formed green product;

(c) curing the compressed product; and

(d) applying a carbonation reducing sealer coating to at least said mounting surface.

One example of a conventional process for forming a green fibre cement product is described in Australian Patent Number 515151, which is incorporated herein in its entirety by reference.

Preferably, the product is a sheet product configured for use as an exterior cladding panel. More preferably, the sealer is applied to at least the back face of the

panel, which face forms the mounting surface. In a more preferred embodiment, the sealer is applied to all surfaces of the panel.

The carbonation reducing sealer is preferably adapted for curing by radiation and ideally by UV radiation. Desirably, the sealer is a co-polymer acrylic sealer.

Preferably, the method includes the additional step of curing the sealer by radiation. More preferably, the radiation is provided by an UV source.

Preferably, the product curing step (d) is performed in an autoclave.

According to a third aspect of the invention, there is provided a durable high performance compressed fibre cement product made in accordance with the method of the second aspect of the invention.

According to an fourth aspect of the invention there is provided a method of making a durable high performance compressed fibre cement product, the method comprising the steps of:

(a) forming by conventional processes a green fibre cement product configured to define at least one exposed surface and a mounting surface;

(b) compressing said formed green product; and

(c) curing the compressed product;

wherein step (b) is controlled such that the cured product exhibits a reduced carbonation gradient through its outer surfaces and internal body portions.

In a preferred form, the method further comprises the additional step of subsequently applying a carbonation reducing sealer, or more preferably a UV curable sealer coating to at least the mounting surface. Preferably, the product curing step (c) is performed in an autoclave.

According to a fifth aspect of the invention there is provided a durable high performance compressed fibre cement product made in accordance with the method of the fourth aspect of the invention.

According to a sixth aspect of the invention, there is provided a method of making a durable high performance compressed fibre cement product, the method comprising the steps of:

(a) mixing a wet fibre cement formulation having a dry weight basis cement silica ratio of between 0.29 to 0.51;

(b) forming from said mixed formulation a green product having one or more outer surfaces and an internal body portion;

(c) compressing said formed product; and

(d) curing the formed and compressed product.

Details of additional mix additives and preferred compositions and ranges are set out in the detailed description.

In a preferred form, the method further comprises the step of applying a carbonation reducing sealer, or more preferably a UV curable sealer coating to one or more of said outer surfaces. Preferably, the product curing step (d) takes place in an autoclave.

In a further aspect, the invention provides an engineered fibre reinforced cement product including a first major surface to which a carbonation reducing sealer is applied and a second opposing major surface to which a carbonation reducing sealer is applied, so as to reduce differential carbonation in the product.

It will be appreciated that the sealer applied to the first major surface can be the same as or different to the sealer applied to the second major surface.

In yet another embodiment, the invention provides a method of mounting an engineered fibre reinforced cement product to a substrate, the method including the steps of:

(a) sealing a first major surface of the product with a carbonation reducing sealer;

(b) fastening the product to the substrate such that the first major surface is directed toward the substrate; and

(c) sealing a second opposing major surface of the product with a carbonation reducing sealer, so as to reduce differential carbonation in the product.

It will be appreciated that the sealer applied to the first major surface can be the same as or different to the sealer applied to the second major surface. In addition, the steps of the method may be performed in any order. For example, the sealer can be applied during the FRC manufacturing process, or alternatively, can be applied shortly before, or even after the product is mounted to the substrate. Moreover, the first and second major surfaces can be sealed simultaneously or at different times. For example, the first major surface can be sealed during the FRC manufacturing process and the

second major surface can be sealed in-situ.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred form of the invention will now be described, by way of example only, with reference to the incorporated tables and accompanying drawing in which:

Figure 1 is a flow chart showing a typical method of making a high performance compressed product in accordance with various aspects of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

The present invention has been developed primarily for use in the manufacture of high performance compressed fibre cement sheets specifically configured for use as external or internal building cladding and lining panels and will be described hereinafter with reference to this application.

Referring to figure 1, there is shown a flow chart 1 of a typical manufacturing process that is suitable for use with preferred forms of the invention configured for producing building cladding panels. Referring to this flow chart, it can be seen that the first step 2 is the manufacture of an FRC green sheet, which in preferred forms is made from a fibre cement composition that falls generally within the ranges set out in the table below.

Dry Ingredients (generic)	Dry Ingredients (preferred)	Acceptable range (% by dry weight)	Preferred range (% by dry weight)	Optimal formula (% by dry weight)
Binder	Cement	20 – 30%	23.5 – 26.5%	25.0%
Aggregate	Silica	58.5 – 68.5%	62 – 65%	63.5%
Fibre	Cellulose pulp	5.5 – 10.5%	7 – 9 %	8.0%
Additives	Alumina trihydrate	2 – 5%	2.5 – 4.5%	3.5%
		Acceptable range	**Preferred range**	**Optimal ratio**
	Cement:Silica	.292 – .513	.362 – .427	.394

This preferred composition has a reduced cement to silica ratio when compared with at least some other prior art formulations, the reduced cement component contributing to an overall reduction in carbon dioxide reactions within the finished product. The cement is typically ordinary Portland cement type 1 and the silica can be milled quartz, preferably around 200 mesh, or any suitable siliceous material that alone, or in combination, yields properties substantially equivalent thereto. Examples of suitable siliceous materials include, but are not limited to, amorphous silica, diatomaceous earth, rice hull ash, blast furnace slag, granulated slag, steel slag, mineral oxides, mineral hydroxides, clays, magnasite or dolomite, polymeric beads, metal oxides and hydroxides, or mixtures thereof.

Preferred fibres include various forms of cellulose fibres, such as hammer-milled Kraft pulp. However, it will be appreciated that other forms of fibres may be used. In a particularly preferred embodiment, the fibre is cellulose wood pulp. Other examples of suitable fibres are ceramic fibre, glass fibre, mineral wool, steel fibre, and synthetic polymer fibres such as polyamides, polyester, polypropylene, polymethylpentene, polyacrylonitrile, polyacrylamide, viscose, nylon, PVC, PVA, rayon, glass ceramic, carbon, or any mixtures thereof.

It should also be noted that optional additional additives can be incorporated in to the composition including density modifiers, dispersing agents, silica fume, geothermal

silica, fire retardant, thickeners, pigments, colorants, plasticisers, dispersants, foaming agents, flocculating agents, water- proofing agents, organic density modifiers, aluminum powder, kaolin, alumina trihydrate, mica, metakaolin, calcium carbonate, wollastonite, polymeric resin emulsions, or mixtures thereof.

In the preferred methods, the sheets are produced using the Hatschek process in the conventional manner well known to those skilled in the art. The Hatschek process uses a rotating drum sieve arrangement to deposit a plurality of layers of de-watered slurry onto an absorbent conveyer until the desired sheet thickness has been achieved.

The preferred green sheet manufacturing process referenced in the flow chart 1 is set to produce a plurality of green sheets of a particular size which are then stacked one upon another and then optionally conveyed to a pressing station. At the pressing station, the sheet size is identified as shown in step 3. Working for example within a preferred compression pressure range of approximately 10 MPa to 30 Mpa, for cladding panels of 1850 mm x 1250 mm, the press is programmed to take into account the sheet size and the stack height and the products are pressed within the pressure targets as shown in steps 4 to 7. This pressure is maintained for a predetermined time period as determined by trial experiment to achieve the desired outcomes in the final product. After pressing, the compressed green products are cured. The curing can be carried out in an autoclave or using any number of other conventional techniques including air curing.

When curing has been completed (step 9), the sheets are typically cut to size (as in step 10) and the edges are finished by passing through a conventional sheet finishing line where they are optionally trimmed to size with an edge router to exact dimensions. The finished FRC sheets are placed in a stack as they come off the sheet finishing line.

Optionally, a carbonation reducing coating is applied to the edges of each FRC before it leaves the sheet finishing line. The coating is preferably curable by radiation, and ideally by UV radiation. However, coatings based on alternative curing mechanisms such as electron beam, microwave and chemical curing may also be used. Preferred sealer formulations include epoxies, urethanes, polyesters, acrylates, and combinations of such formulations.

In some preferred forms of the invention, the finished FRC sheet is then coated on all six sides (the front face and mounting face being the two major faces, and the four edges) with a sealer of the same kind as shown in step 10. This may be done by first

manually roll coating or spraying the sealer on the edges of the stack of FRC sheets and then individually roll coating the sealer on the face and back of an FRC sheet using a conventional roll coater. Typically, a stack of 16 sheets is edge coated at one time to maximise efficiency, but to prevent drying before the FRC sheets go through the roll coater and are cured. Preferably, the coating thickness is in the range of 15 to 50 microns.

Finally, where the applied carbonation reducing sealer is a UV sealer, the FRC sheet is then cured with conventional UV light at a suitable predetermined intensity and duration, as determined by the specific sealer formulation, as noted in step 13. The UV lights preferably shine above the FRC sheet and through a 300 to 400 mm gap in the conveyor to cure the back and edges of the FRC sheet at the same time. The intensity of the UV lights needs to be regularly monitored to maintain consistent curing. If the intensity of the light subsides, the curing is not as strong which could lead to product imperfections.

It will be appreciated that the invention as described illustrates numerous ways in which an FRC product of reduced propensity to carbonation or differential carbonation and hence improved durability can be produced. For example, the reduced cement to silica ratio generally reduces carbon dioxide reactions within the product, thereby minimising any differential carbonation that may apply across various sheet boundaries and through the final sheet itself.

Similarly, it is believed that controlling permeability and rigidity (as may be affected by density), allows carbonation gradients across a sheet to be controlled, particularly where the various surfaces may have different levels and types of sealing.

Finally, the factory application of a sealer, and more particularly a carbonation reducing sealer such as an acrylic UV curable sealer, to at least the mounting surface of the panels in a controlled fashion, ensures that there is no risk of the panels being mounted without adequate sealing on the mounting surface, thereby again reducing the potential carbonation differential of the finished panel once it has been installed. There is the added advantage with original manufacturer pre-sealing of increasing the longevity of the base board during transport and storage. It also makes it significantly easier for cladding panel finishers and installers to apply additional coatings and the like. Certainly, sealing on all six surfaces of a panel greatly reduces the chance of severe

differential carbonation across a panel, particularly as can occur when one or more sides are left untreated.

Each of the above discussed process steps and features separately define inventive methods of making improved compressed FRC compressed products. Furthermore, when these process steps and features are combined, which can be done in numerous different ways, there is a synergistic interaction that enables production of products having vastly superior performance characteristics over the prior art.

Finally, it will be appreciated by those skilled in the art that while the inventive aspects are particularly suited to FRC compressed sheeting and panels, they are equally applicable to other FRC products. Similarly, while the preferred examples illustrate particular compositions and pressure ranges and sealants, the invention may be embodied in many other forms to achieve the same advantageous results.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. An engineered fibre reinforced cement product including a first major surface to which a carbonation reducing sealer is applied and a second opposing major surface to which a carbonation reducing sealer is applied, so as to reduce differential carbonation in the product.

2. A product according to claim 1, wherein a carbonation reducing sealer is applied to all surfaces of the product.

3. A product according to any one of the preceding claims, wherein the carbonation reducing sealer applied to at least one of said first and second major surfaces is a co-polymer acrylic UV curable sealer.

4. A method of mounting an engineered fibre reinforced cement product to a substrate, the method including the steps of:

sealing a first major surface of the product with a carbonation reducing sealer;

fastening the product to the substrate such that the first major surface is directed toward the substrate; and

sealing a second opposing major surface of the product with a carbonation reducing sealer, so as to reduce differential carbonation in the product.

5. A method according to claim 4, wherein the carbonation reducing sealer applied to at least one of said first and second major surfaces is a co-polymer acrylic UV curable sealer.

DATED this 16th day of January, 2004
BALDWIN SHELSTON WATERS
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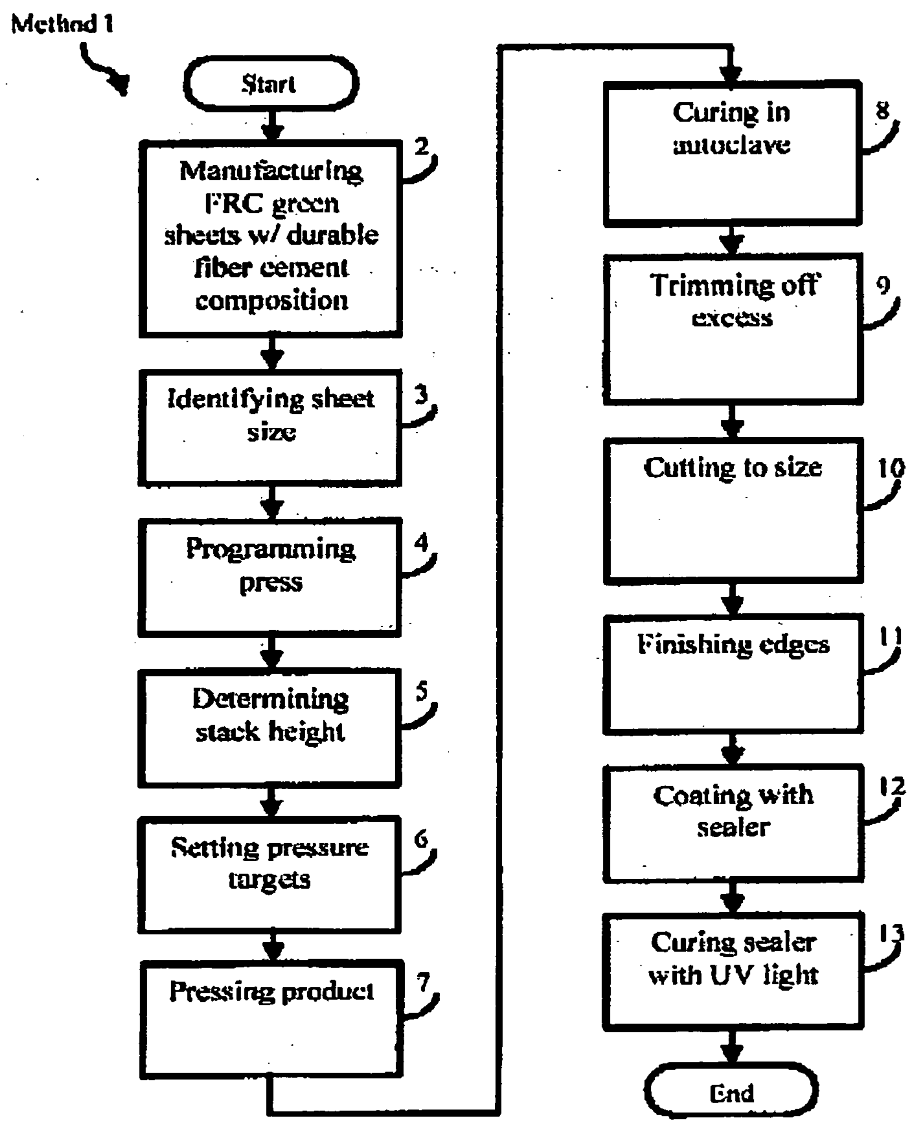
Figure 1


Method 1
Start
Manufacturing FRC green sheets w/ durable fiber cement composition
2
Identifying sheet size
3
Programming press
4
Determining stack height
5
Setting pressure targets
6
Pressing product
7
Curing in autoclave
8
Trimming off excess
9
Cutting to size
10
Finishing edges
11
Coating with sealer
12
Curing sealer with UV light
13
End